STUDY TEAM ON WATTS FROM WASTE

interim report
to the
minister of the environment

july, 1973

Ministry
of the
Environment
Ontario

I N T E R I M R E P O R T

of the

STUDY TEAM ON WATTS FROM WASTE

to the

Minister of the Environment

July 1973

The Hon. James A.C. Auld announced in the Legislature on May 4, 1973 the government's intention to examine in detail the feasibility of using specially prepared refuse as a fuel in power generating stations.

The Minister announced that the following would participate in the Study Team:

Tony O'Donohue, P.Eng.,Chairman
Ontario Hydro
Metro Works Department
Town of Mississauga
Ministry of the Environment

The first meeting was held on April 25, 1973 and meetings have been held every week since then - a total of ten meetings in all.

The group chose as its name, the Study Team on Watts from Waste.

Members of the Team, accompanied by the Hon. James A.C. Auld, visited St. Louis on April 30 to examine the progress being made by the City of St. Louis and Union Electric. In St. Louis a consulting engineering firm, Horner & Shifrin Inc. was engaged by the City and Union Electric with EPA funding to examine the feasibility of using specially prepared refuse as a fuel in an ordinary utility boiler. Refuse is milled and burned in suspension in one of the utility's furnaces.

The trip to St. Louis answered many questions but those involved at Union Electric were not able to answer all questions relating to possible future boiler problems. Up until the present time, there has been no evidence of furnace or boiler tube problems and corrosion has not been encountered on the boiler tubing. Ontario Hydro engineers grilled the engineers from Union Electric on this aspect as it seems to be the one major set-back which could occur. However, so far the St. Louis operation has been successful and it has burned approximately 16,000 tonnes*/ of refuse at a 10-15% ratio in a 125 megawatt utility boiler.

The Toronto area with its two fossil fuel generating stations - the Lakeview and the Hearn - could become involved in the disposal of

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*/ See Appendix I

waste, using specially prepared refuse as a fuel in its boilers.

At present the Hearn Generating Station uses natural gas and therefore has no electrostatic precipitators: the Lakeview Generating Station uses pulverized coal and has electrostatic precipitators. Since the burning of refuse produces a high quantity of ash, particulate matter must be captured from the flue gas by the use of electrostatic precipitators. Lakeview Generating Station is therefore the logical plant to use for this first project.

The key to the whole operation of recycling is in the separation of refuse at the source or at the plant. Assuming that separation at the source is not practical, separation at the plant has to be the answer. The Team has been looking at equipment or proposals for equipment to do the separating.

The Team visited M.&T. Chemicals Inc. at Elizabeth, New Jersey on May 25. The main item on display there was a system for classification of refuse. After refuse has been through the hammer mill, it is then run through a vertical-gravity-air system so that the various components of the refuse can be sorted. This seemed to be a small but successful demonstration and could possibly be used in the Toronto area operation.

Toronto Area Processing Plant Proposal

In simple terms, the Toronto processing plant could work like this: - the refuse is delivered to a processing transfer plant by refuse collection vehicles. The processing plant would be located to minimize haulage distances - approx. 8 km radius (5 miles) - from the refuse collection routes and large enough - about 1000 tonnes/day - to make the processing economically viable.

The refuse is dumped in a covered storage area and fed to a conveyor system by front-end loader where the material which can be easily recycled (paper, cardboard, etc.) will be picked off by manual labour. The refuse is then shredded in a large hammer mill - approx. 750 kw (1000 hp) - to bring the material to a more homogeneous consistency. Screening, air classification, magnetic separation and mechanical sorting

then take place to separate the ingredients for recycling.

Finally, the combustible or fuel portion of the classified refuse is shredded for a second time. The refuse fuel is then shipped to Hydro's utility boiler where it will replace a portion of the coal now being used to generate electricity.

Recycling - an Integral Part of Proposal

The Team also had meetings with various groups of companies and organizations involved in some way with the production and disposal of waste and with an interest in recycling.

The first meeting was held with representatives of the plastics industry. In this case there is concern about the amount of chlorine in disposable plastics. It was fairly well agreed that chlorine was only available in large quantities in polyvinylchlorides (PVC) and there was some agreement that the plastics industry operating as a unit could control its own operations rather than have the Team request legislation. Further meetings will be held on this so that the matter can be explained in more detail to the Minister.

The Team met with representatives of the metal containers manufacturing associations to explore the possibility of an overall arrangement so that scrap and metal containers could be recycled once they have gone through the separation system. This was agreed to in principle and the question of involvement and price will have to be worked out later.

The Team also met with the representative of the glass companies to discuss the possibility of sorting glass into various colours for recycling which would obviously result in a higher price. Testing will be done this summer and further information will be forthcoming.

It was generally accepted that the development of a 1000 tonne per day plant would require refuse from the west section of Metropolitan Toronto and Mississauga, and officials from these two municipalities have supplied the following information.

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Mississauga

The Town of Mississauga is currently producing approximately 168,300 tonnes of refuse per year from a population of 192,000 (including Port Credit and Streetsville). With the rapid growth forecast in this area, refuse in the amount of 247,500 tonnes is expected to be generated from a population of approximately 300,000 persons in 5 years.

The Town of Mississauga is currently disposing of all wastes by the sanitary landfill process. However available landfill areas have only a few more years operation left before they are filled.

Regional government is being established in Peel County as of January 1, 1974 and the disposal of refuse will become a regional responsibility at that time. The degree of participation (if any) in the system which may be derived from this study will therefore be a decision of the future regional government.

Mississauga has expressed more than passing interest on the environmental impact of the proposed system since Lakeview Generating Station is located in Mississauga and the terms of reference for the study have been designed to produce answers in this regard.

Metropolitan Toronto

According to the Master Plan for refuse disposal in Metropolitan Toronto as set out in the 1967 MacLaren Report, the following refuse quantities will be produced by 1976 from the westerly sector of the region.

Planning Districts 7, 8 and 9 (Borough of Etobicoke - see Fig. V-1 attached) will generate 127,800 tonnes per year of municipally collected refuse and 159,210 tonnes per year of privately collected industrial and commercial refuse, increasing to 155,160 tonnes and 215,280 tonnes respectively by 1986.

District 18 (easterly part of Town of Mississauga) will generate 49,140 tonnes per year of municipally collected refuse and 78,210 tonnes per year of privately collected industrial and commercial refuse, increasing to 86,580 tonnes and 179,010 tonnes respectively by 1986.

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In addition the area east of the Borough of Etobicoke but west of Yonge Street Districts 10, 3, 2, west half of 11, west half of 4 and west half of 1 will generate approximately 405,810 tonnes per year of municipally collected refuse and 207,810 tonnes per year of privately collected industrial and commercial refuse. This material will be disposed of at distant sanitary landfill sites (by rail haul), the Dufferin Incinerator and possibly at private sanitary landfill sites outside the boundaries of Metropolitan Toronto.

Also according to the master plan, the refuse disposal facilities in the Etobicoke area recommended for the year 1976 were to be the North Thackeray Sanitary Landfill Site located north of Steeles Avenue at Kipling Avenue, and a refuse disposal facility (transfer station or incinerator) located on Kipling Avenue south of Dundas Street. Due to difficulties in obtaining these sites Metropolitan Toronto has acquired two alternative sites which could be used either for transfer operations or as incinerator sites. One of these sites is located on Kipling Avenue at Horner Avenue,the other at Disco Road west of Renforth Drive (adjacent to the Borough of Etobicoke Works Yard where the Municipal collection vehicles are garaged).

Because it has not been possible to obtain sanitary landfill sites to serve the westerly sector of Metropolitan Toronto and the possibility of transfer hauling the refuse long distances to distant landfill sites outside Metro, the alternative possibility of constructing large incinerators is being studied. In this connection an Engineering Report prepared by Gore and Storrie Ltd., in association with Metcalf and Eddy Inc., has been prepared which recommends that a 1080 tonnes/day steam generating refuse incinerator be constructed on the site at Kipling Avenue and Horner Avenue. Rezoning of the site has already been obtained to allow for the construction of this plant. Due to the possibility of rail hauling part of the refuse to sanitary landfill sites which would normally be delivered to this plant, a delay in its construction has been necessary.

Metropolitan Toronto has immediate and urgent problems since many of the recommendations in the Master Plan have been difficult to implement and in no other place is the problem more critical than in

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the western section of Metro. Therefore anything which could be done in this area would be most helpful.

Table I gives a clearer and more detailed picture of refuse disposal in Metropolitan Toronto in 1972.

Table II gives a detailed account of the dimensions of the refuse disposal crisis which will be encountered in Metropolitan Toronto during the next five years.

Use of Refuse as a Fuel and Recycling

The concept of producing energy from municipal refuse, although not new in Europe, is not widespread in North America. It should be analyzed in light of today's technology and the goal of the Ministry of the Environment relative to waste disposal. The Minister has stated that "the best possible way of dealing with waste disposal is to have all waste recycled, if at all possible and it is the long term goal of the Provincial Government to try and generate interest and develop methods which will ensure that this becomes a reality".

The project which the Watts from Waste Study Team has been considering must be outlined in order to present the assessment in a logical order.

Watts from Waste Conceptual Outline

European countries have used the heat produced from incinerators for the past 20 years. This was brought about mainly because energy was scarce and expensive. Fossil fuels had to be imported and therefore it made good economic sense to use waste heat. The European incinerator burns refuse without any preparation of the refuse - everything goes through the furnace. Metals are removed in the ash. The heat captured is used to heat buildings or to produce electricity. Very often the incinerator is adjacent to the power plant. It is therefore an incinerator first with waste heat used and metals recovered after incineration.

The Study Team proposes a different route from the European system but with the same end in mind plus additional emphasis on recycling and specially prepared refuse as a fuel in a utility boiler at

the Lakeview Generating Station. Lakeview is proposed because of its location and its existing air cleaning equipment.

It is generally accepted that there is sufficient calorific content in municipal refuse to consider it as a source of energy. However, processing of the refuse, or more specifically grinding, is an essential step before a portion of the fossil fuel can be replaced with milled refuse. In order to achieve maximum efficiency, the milled refuse must be separated into two fractions - the combustibles and the non-combustibles. The combustible component of the refuse can be used to replace a portion of the fossil fuel normally fired in the boiler- This may vary from 10-20% replacement on a calorific basis. The non-combustible component is available for recycling and markets are already available for glass and scrap metal.

Analysis of Municipal Refuse

Municipal refuse was sampled in Toronto from 12 - 16 September 1966 and the average composition of refuse can be broken down as follows:

Combustibles

Paper and Cardboard	39.5%
Food Waste	32.4%
Vegetation	6.5%
Plastic	2.6%
Rags	1.5%
Wood	1.1%
Other Misc. Combustibles	1.1%
	84.7%

Noncombustibles

Glass	8.0%
Cans	5.5%
Metal - Ferrous	0.3%
- Nonferrous	0.1%
Other Misc.Noncombustibles	1.4%
	15.3%
Total sample	100.0%

Impact Assessment

The concept of using municipal refuse as a source of energy will

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be assessed on the following bases:

a) energy
b) recycling and reclamation
c) does it satisfy government policy?
d) social implications

a) energy

The major advantages of refuse as a source of fuel are:

1) refuse has a substantially lower sulphur content than the coal it replaces.
2) since paper is the major part of the energy component a renewable resource replaces a non-renewable resource such as coal or oil.
3) municipal refuse becomes a source of energy with considerable potential. The demand for energy is increasing at a substantial rate.

b) recycling and reclamation

In order for recycling and reclamation to become a viable alternative for present methods of disposal, markets must be available for the components which can be separated. Although the use of the combustible fraction as a source of energy is not the traditional type of recycling most people know, the project is acting as a catalyst to spark recovery of various materials such as:

1) corrugated paper to the extent that it is practical to separate this material by hand.
2) ferrous metals
3) glass

c) government policies

Recycling and the recovery of waste heat from refuse line with the announced policies of the Provincial Government.

d) social implications

Recycling is a concept which has received much attention in the past few years. Refuse disposal by means of landfill has come under attack because it implies that no efforts to recycle are being made. It

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must be accepted that the need for landfill for a portion of our waste will always be with us. The project as outlined will do a great deal to convince the public that all parties involved are serious about recycling and are taking positive steps to re-use finite resources and to prevent further deterioration to the environment.

Air Pollution Impact of Refuse Burning at Lakeview

The following is a preliminary report based on information presently available. Data necessary for a full study of air pollution is not available and assumptions and estimates have been made to make this preliminary evaluation.

Particulate Emissions

Assume 10% refuse firing i.e. 10% heat value of coal. Based on 2890 kc/kg (5200 BTU/lb) as calorific value for refuse, then approximately 1 kg is replaced by 2½ kg refuse fuel.

Assume 8% ash in coal

Assume 15% ash in refuse

Assume 75% of ash goes to dust collectors

Then for 100 kg coal, ash to dust collector

= 100 x .08 x .75 = 6 kg ash

for 10% refuse firing

90 kg coal x .08 x .75 = 5.4 kg ash

25 kg refuse x .15 x .75 = 2.8 kg ash

8.2 kg ash

i.e. with refuse firing particulate to the dust collectors is increased by 37%. Lakeview Generating Station has 8 boilers each with a capacity of 90 tonnes/hour.

Assuming 60% capacity, then this represents an overall increase of approximately 6% in the particulate loading to the dust collectors; alternatively burning 545 tonnes/day of refuse over 24 hours represents an increase in particulate loading of approximately 3%.

Neither of these increases would cause violations of existing regulations assuming the efficiency of the dust collectors remains the same.

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It should be appreciated that refuse firing will change the gas characteristics to the dust collectors (Electrostatic Precipitators); however these changes would not be expected to materially affect precipitator performance. Should the gas velocity in the precipitators increase, then a small increase in particulate emissions would occur. The expected velocity increase has been taken into consideration and the impingement concentrations on this basis and with present land usage will not be expected to exceed the present standards.

Sulphur Dioxide

The concentration of sulphur dioxide will be somewhat reduced because of the small quantities of sulphur in refuse. Existing requirements for SO_2 control will be unaffected.

Chlorides and Fluorides

From the Kaiser report of June 30, 1971 approximately 60 - 65% of the chlorine remains as HCL in the flue gas.

Metro analyses of Hamilton and St. Catharines refuse averages 2600 ppm chlorides and 2.1 ppm fluorides. (See attached Tables III).

The Kaiser report also shows a maximum chlorine content (equivalent HCL) in the flue gases as approximately 1800 ppm or 1.33 grams/hour.

Using the latter figure the addition of refuse will not cause a violation of present impingement standards.

Fluoride content in the refuse is apparently much less than chlorides and based on figures in the Kaiser report is not expected to present impingement problems.

Nitrous Oxides

The increase in NO_x emissions due to refuse firing is negligible and is not expected to cause impingement concentrations in excess of the regulations.

This conclusion is based on coal producing 9 kilos NO_x per tonne burned and from the Kaiser report refuse averages 1.35 kilos/tonne.

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From information presently available, the firing of refuse to replace the heat value of 10% coal in one boiler at Lakeview will not cause emissions to atmosphere from the existing stacks in excess of present air quality standards. The precipitators will have to handle a small increase in particulate matter but SO_2 emissions will be reduced.

It is generally agreed that attitudes in North America towards non-renewable resources - especially fossil fuels - are dramatically changing. A few years ago waste heat from incinerators was scoffed at by most North Americans. Today, in the U.S., brown outs and black outs are a regular occurrence. Everyone knows about the energy crisis. It is respectable now to recover waste heat from refuse incineration.

Ontario Hydro representation on the Study Team has been responsible for much of the information dealing with furnace operation. Although Hydro's contribution so far has been extensive many of their queries cannot be answered without more detailed work. In this respect, Hydro requested that they have overall responsibility in the feasibility report for matters dealing with combustion and the products of combustion. The Study Team agrees with this approach on the understanding that the services of the consulting engineer and the Study Team be fully utilized.

The Study Team as can be observed, has done a great deal of work in the past ten weeks but much more detailed work has to be carried out in the months ahead and for this it is generally agreed that the services of a consulting engineer are required. It was felt that the obvious choice would be to obtain the services of the consulting engineering firm of Horner & Shifrin Inc. who have been involved for the past two years in the St. Louis operation. It was noted that this consulting engineering firm had also been awarded contracts in New York and Indianapolis to carry out feasibility studies for heat recovery from refuse in these cities. It is therefore to our advantage to acquire the services of this consulting engineering firm and we proposed the following terms of reference.

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TERMS OF REFERENCE

FOR

AN OVERALL STUDY ON THE UTILIZATION OF REFUSE AS A SUPPLEMENTARY FUEL IN A UTILITY BOILER WITH GLASS, METALS AND OTHER MATERIALS REMOVED FOR RECYCLING

The report shall be in three sections:

SECTION I will be prepared by the consulting engineer in consultation with Metro, Mississauga, Air Management, Waste Management, Ontario Hydro. The consultant will also draw on other sources as required for the preparation of the report.

The thrust of this Section will be on refuse as fuel with metals, glass and other materials separated for recycling. It will examine in detail handling, processing and separation of refuse.

Scope:

(i) Quantity of solid waste available. From the records of the Metropolitan Toronto Works Department and the Town of Mississauga, present and projected solid waste quantities will be scrutinized to determine an approximation of that portion of the waste which could be suitable for use as power plant fuel. Also other materials in the waste such as metals and glass will be examined for recycling purposes.

(ii) Quality of solid waste available. Based upon data which is presently available, a summary of analyses of solid waste and solid waste ash will be presented. The consulting engineer will analyse refuse over a period of one week.

(iii) Recycling - a major part of the appraisal. Refuse will be prepared by shredding and a separation system will be used to extract the combustibles. This will leave other materials such as glass and metals available for recycling and the consulting engineer will examine and report on this in detail. The report will study and report on methods and equipment for:

(a) basic processing plant of approx. 1000 tonnes/day -

1. location of processing plant
2. transport facilities to processing plant
3. receiving at processing plant
4. storage of materials at processing plant
5. facilities for materials recoverable from process residue
6. manpower requirements at processing plant

(b) Lakeview Generating Station handling facilities (600 tonnes/day) -

1. transport from processing plant
2. receiving facilities for refuse fuel
3. storage of refuse fuel at Lakeview
4. manpower requirements at Lakeview

(iv) Environmental Considerations. The anticipated relative environmental effects of the process will be assessed. Matters to be given consideration include:

(a) air pollution control
(b) dust and blowing paper particles
(c) aesthetic considerations
(d) truck traffic
(e) space requirements
(f) noise
(g) land management

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SECTION II will be prepared by the Ontario Hydro with assistance from the consulting engineer, Air Management, Waste Management, Metro and Mississauga.

This section of the report will contain an assessment of the effects of burning solid waste as supplementary fuel in power plant boilers.

Scope:

(i) Factors which will be considered are:

(a) refuse firing
(b) corrosion potential
(c) slagging
(d) carry over of unburned particles
(e) stability of operation
(f) manpower requirements
(g) ash handling and quality
(h) combustion control
(i) erosion
(j) bridging of in-ash hoppers
(k) ash lagoons
(l) plugging of air pre-heaters and other restricted flow areas

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(m) outages of either boilers or refuse firing equipment
(n) risks

(ii) It will also look into the anticipated environmental effects of the burning of refuse as a supplementary fuel.

(a) particulate emissions
(b) nitrogen oxides
(c) sulfur oxides
(d) chlorine
(e) heavy metals
(f) carcinogens
(g) odors
(h) water pollution
(i) effects on pollution control equipment

(iii) Boilers available in the Toronto area. A summary of the principal characteristics will be prepared, in order to determine those units which show the greatest promise of being adapted to use solid waste as a supplementary fuel.

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SECTION III will be prepared by the consulting engineer with input from Metro, Mississauga, Ontario Hydro, Air Management, Waste Management and others as required.

This section of the report will contain an overall view of the project with emphasis on economics, environmental and community effects.

Scope:

(i) Economics. Estimates will be prepared for the capital and operating costs of the various components. Such estimates will include the costs of processing, transport and firing but will not include solid waste collection. The estimates will be order-of-magnitude only, since they will not be based upon detailed design. Estimates will be based on 1973 dollars and will include consideration of:

(a) processing costs
(b) transport costs
(c) costs at power plant for receiving and firing
(d) value of fossil fuel replaced
(e) incremental costs of power plant operation
(f) potential value of recovered materials

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(g) costs of alternate methods of solid waste disposal

(ii) Overall Community Effects. An appraisal will be made of the effects of applying the process upon the community, including:

(a) economic attractiveness
(b) conservation of irreplaceable fossil fuel
(c) potential recycling of recoverable materials
(d) effects upon land management
(e) environmental attractiveness

(iii) Agreements required to develop the project.

(iv) The findings and conclusions of the appraisal will be summarized at the beginning of the report. Fifty copies of the report will be presented to the Ministry of the Environment.

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CONCLUSIONS

The feasibility study will be completed by 15 October 1973. The Study Team will work with the consulting engineer in the preparation of the report to ensure that the report which is presented to the Ministry of the Environment will be in such detail that decisions can be made immediately for detailed design drawings once the financing and policy decisions have been made.

RECOMMENDATIONS

(1) That the consulting engineering firm of Horner & Shifrin Inc. be retained for the feasibility study as outlined in the proposed Terms of Reference.

(2) That the feasibility study be completed by 15 October 1973 at a cost not to exceed $24,500.

(3) That the Study Team participate with the consulting engineer in the preparation of the feasibility study.

ACKNOWLEDGEMENTS

I wish to thank the following members of the Study Team who participated in the drafting of this interim report:

I. McKerracher, P.Eng., Director of Refuse Disposal, Metro Works Dept.
H. Jackson, P.Eng., Senior District Engineer, Air Management Branch, Ministry of the Environment
C. Chisamore, P.Eng., Acting Assistant Director, Waste Management Branch, Ministry of the Environment
W. Anderson, P.Eng., Town Engineer, Town of Mississauga
W. James, P.Eng., Process Equipment Development Engineer, Ontario Hydro

Tony O'Donohue, P.Eng.,
Chairman

July 10, 1973

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2. Horner & Shifrin, Inc., Energy Recovery from Waste, U.S. Environmental Protection Agency, 1972.
3. Elmer R. Kaiser and Arrigo A. Carotti, Municipal Incineration of Refuse with 2% and 4% Additions of Four Plastics: Polyethylene, Polystyrene, Polyurethane, Polyvinl Chloride, New York University, Bronx, New York, June 30, 1971.
4. James F. MacLaren Limited in association with Black & Veatch, Report and Technical Discussion on Refuse Disposal for Municipality of Metropolitan Toronto, May 1967.
5. Ontario Research Foundation, Analysis of Gaseous and Particulate Emissions from a Metro Toronto Refuse Incinerator, Sheridan Park, June 1971.
6. Stanford Research Institute, Menlo Park, Calif., The Plastics Industry in the Year 2000, prepared for The Society of the Plastics Industry, Inc., New York, April 1973.
7. Union Electric Company, St. Louis, Mo., Solid Waste as a Utility Fuel, April 1, 1973.

Appendix I

Metric System

Note:

As most countries are now converting to the metric system, it was decided to use this system in preparing the Interim Report.

As a guide to understanding the metric system, the following conversion factors are listed:

Conversion factors (approximate)

	from:	to:	multiply by:	reciprocal:
length	inch	mm	25,4	0,039 37
	inch	cm	2,54	0,393 70
	ft.	m	0,304 8	3,280 84
	yd.	m	0,914 4	1,093 61
	mile	km	1,609 34	0,621 37
	int. naut. mile	km	1,852	0,539 96
	micron	μm	1	1
	millimicron	nm	1	1
	angstrom	nm	0,1	10
	x-unit	pm	0,1	10
area	sq. inch	cm^2	6,451 6	1,155 00
	sq. ft.	m^2	0,092 90	10,763 91
	sq. yd.	m^2	0,836 13	1,195 99
	acre	ha	0,404 69	2,471 05
	sq. mile	km^2	2,589 99	0,386 10
volume	cu. inch	cm^3	16,387 06	0,061 02
	cu. ft.	m^3	0,028 32	35,314 67
	cu. yd.	m^3	0,764 55	1,307 95
	register ton	m^3	2,831 68	0,353 15
	acre-ft.	m^3	1233,482	$8,107 \times 10^{-4}$
capacity	minim	ml	0,059 19	16,893 60
Imp. measure	fluid oz.	ml	28,413 06	0,035 20
	pint	l	0,568 26	1,795 75
	quart	l	1,136 52	0,879 88
	gallon	l	4,546 09	0,219 97
	bushel	hl	0,363 69	2,749 62
weight or mass	grain	mg	64,798 91	0,015 43
	dram	g	1,771 84	0,564 38
avoir-dupois	oz.	g	28,349 52	0,035 27
	lb.	kg	0,453 59	2,204 62
	cwt.	kg	45,359 24	0,022 05
short	ton	t (metric)	0,907 18	1,102 31
troy or apothecary	oz.	g	31,103 48	0,032 15
	lb.	kg	0,373 24	2,679 23
frequency	cps	Hz	1	1
velocity	ips	m/s	0,025 4	39,370 1
	fps	m/s	0,304 8	3,280 84
	fpm	m/s	0,005 08	196,850
	mph	m/s	0,447 04	2,236 94
	mph	km/h	1,609 34	0,621 37
acceleration	in/s^2	m/s^2	0,025 4	39,370 1
	ft/s^2	m/s^2	0,304 8	3,280 84
magnetic flux	maxwell	weber (Wb)	10^{-8}	10^8
	maxwell	nanoweber (nWb)	10	0,1
mag. flux density	gauss	tesla (T)	10^{-4}	10^4
	gauss	mT	0,1	10

	from:	to:	multiply by:	reciprocal:
force	ounce-force	N	0,278 01	3,596 94
	pound-force	N	4,448 22	0,224 81
	kip	kN	4,448 22	0,224 81
	poundal	N	0,138 25	7,233 01
	dyne	μN	10	0,1
	kilogram-force (kp)	N	9,806 65	0,101 97
pressure	psi	kPa	6,894 76	0,145 04
	pound-force/$ft.^2$	Pa	47,880 26	0,020 89
	ksi	MPa	6,894 76	0,148 04
	short ton-force/$in.^2$	MPa	13,789 49	0,072 52
	kp/m^2	Pa	9,806 65	0,101 97
	kp/cm^2 technical at.	kPa	98,066 5	0,010 20
	dyn/cm^2	Pa	0,1	10
	bar	Pa	10^5	10^{-5}
hydrostatic units	mm of mercury (torr)	mbar	1,333 22	0,750 06
	normal atmosphere	bar	1,013 25	0,986 92
	inches of mercury	mbar	33,863 9	29,530 0
	mm of water (4° C)	Pa	9,806 65	0,101 97
	in. of water (conv.)	mbar	2,490 89	0,401 46
energy	ft.-lb.-force	J	1,355 82	0,737 56
	Btu (int.)	kJ	1,055 06	0,947 82
	therm	MJ	105,506	$9,478 \times 10^{-3}$
	horsepower-hour	MJ	2,684 52	0,372 51
	calorie (int.)	J	4,186 8	0,238 85
	erg	J	0,1	10
	kgf-m	J	9,806 65	0,101 97
	kWh	MJ	3,6	0,277 78
	watt-hour	kJ	3,6	0,277 78
	electron-volt	aJ	0,160 21	6,242
power	Btu/h (int.)	W	0,239 07	3,412 14
	Btu/s (int.)	kW	1,055 06	0,947 82
	ft.-pound-force/h	mW	0,376 62	2,655 22
	HP metric	kW	0,735 50	1,359 62
	HP electr.	kW	0,746	1,340 48
	HP mech. (UK)	kW	0,745 70	1,341 02
	HP boiler	kW	9,809 5	0,101 94
	kp·m/s	W	9,806 65	0,101 97
conductance	mho	siemens (S)	1	1

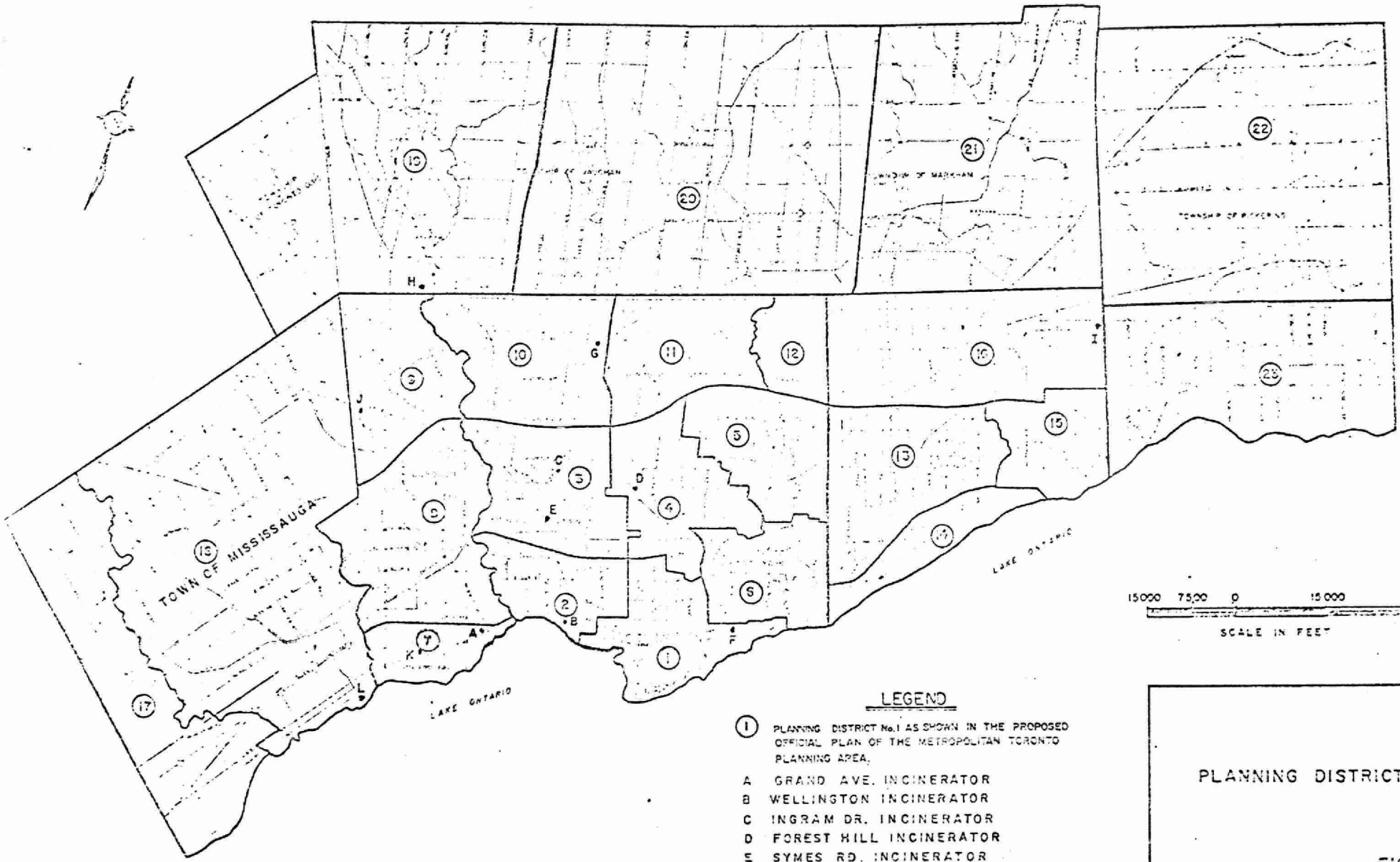
In 1972, refuse handled at Metropolitan Toronto facilities were as follows.

TABLE I

Facility	Location	Tonnage	Remarks
Incineration	Grand	33,069	To be phased out as an incinerator in 1973 and converted to a temporary transfer station.
	Wellington	36,723	To be phased out as an incinerator in 1973 and converted to a temporary transfer station.
	Forest Hill	20,575	To be phased out as an incinerator in 1974 and converted to a transfer station.
	Symes	88,772	To be phased out as an incinerator in 1974.
	Commissioners	116,255	To be enlarged to 900 tons/day by 1975.
	Ingram	82,083	
	Dufferin	94,612	
Landfill	Beare Road	580,740	To be filled by 1977
	South Thackeray	392,605	To be closed to private haulers October 31, 1973 and completed in 1974.
Total		1,445,434	

Note: The weights given above are in short tons rather than in metric tonnes.

.../



LEGEND

(1) PLANNING DISTRICT No.1 AS SHOWN IN THE PROPOSED OFFICIAL PLAN OF THE METROPOLITAN TORONTO PLANNING AREA.

A GRAND AVE. INCINERATOR
B WELLINGTON INCINERATOR
C INGRAM DR. INCINERATOR
D FOREST HILL INCINERATOR
E SYMES RD. INCINERATOR
F COMMISSIONER ST. INCINERATOR
G DUFFERIN INCINERATOR
H THACKERAY LANDFILL
I BEARE RD. LANDFILL
J DISCO RD. SITE
K KIPLING HORNER SITE
L LAKEVIEW GENERATING STATION

PLANNING DISTRICTS

FIG. V-1

MUNICIPALITY OF METROPOLITAN TORONTO

Refuse Disposal from 1970 and Projected to 1978

GENERATION— in tons	1970	1971	1972	1973	1974	1975	1976	1977	1978
Municipally Collected	850,108	979,360	1,077,072	1,110,000	1,150,000	1,175,000	1,210,000	1,250,000	1,290,000
Privately Collected	405,085	416,320	368,362	420,000	440,000	485,000	530,000	570,000	615,000
Total Refuse	1,255,193	1,395,680	1,445,434	1,530,000	1,590,000	1,660,000	1,740,000	1,820,000	1,905,000
DISPOSAL FACILITIES— available in tons									
Grand	35,741	36,092	33,069	7,700	—	—	—	—	—
Wellington	53,715	51,764	36,723	15,300	—	—	—	—	—
Ingram	94,381	92,057	82,083	90,000	90,000	90,000	90,000	90,000	90,000
Dufferin	117,495	115,874	94,612	110,000	110,000	110,000	110,000	110,000	110,000
Commissioners	138,806	133,853	116,255	100,000**	70,000**	140,000**	210,000	210,000	210,000
Symes	86,740	87,180	88,772	90,000	90,000	—	—	—	—
Forest Hill	21,011	21,238	20,575	20,000	20,000	—	—	—	—
Thackeray Landfill	315,566	365,696	392,605	400,000	175,000	—	—	—	—
Beare Road Landfill	391,734	491,926	580,740	600,000	600,000	600,000	600,000	300,000	—
Total Disposal Capability	1,255,193	1,395,680	1,445,434	1,433,000	1,155,000	940,000	1,010,000	710,000	410,000
#Deficiency—(no capability to handle)	—	—	—	97,000	435,000	720,000	730,000*	1,110,000*	1,495,000*

This chart reflects situation when Pickering Sites or Rail Haul not available.

**Restricted operation due to complete plant reconstruction.

* These figures might be reduced 5 to 10% if recycling can be made a viable operation.

Table II

Note: The weights given above are in short tons rather than in metric tonnes.

REFUSE ANALYSIS

The results are expressed on dry weight basis.

ORIGIN & DATE of SAMPLE	MOISTURE %	ASH %	ALUMINUM ppm	LEAD ppm	TIN ppm	ZINC ppm	CHLORIDES ppm	FLUORIDES ppm
ST. CATHARINES								
MAY 21	24.6	30.8	3,300	200	(*)	230	2,200	2.6
22	31.5	24.8	7,800	210	(*)	330	1,900	2.6
23	26.4	22.7	5,900	520	(*)	620	1,700	2.3
24	29.0	37.8	6,700	140	(*)	210	2,100	1.5
25	29.1	21.9	2,600	140	(*)	380	3,000	2.0
HAMILTON								
MAY 22	16.8	26.0	21,400	250	80	540	3,800	1.5
23	26.1	34.0	4,600	250	(*)	440	2,400	1.9
24	27.1	33.0	4,500	220	(*)	310	3,400	2.6
25	23.2	41.5	6,800	260	(*)	400	3,100	1.9

(*) Below detection limit. - Due to the low density of the dry sample detection limit for TIN was 60 ppm.

Table III

June 1973

TERMINAL STREAM: GEORGIAN BAY

DATE	ISSUED TO

BROWN CAT. No. 23-115 PRINTED IN U. S. A.